Biomedical Evaluation of Biblical lore
(The search for history in the Bible)

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Introduction

Is the Bible historically reliable? Were the biblical characters, Abraham and Sarah, Moses and Aaron, David and Solomon persons who really existed, or do their names merely represent glorious mythic figures who symbolized ideas or, at most, represent tribes that wandered and dwelled in the Near East—Mesopotamia, Canaan and Egypt? These questions and the issues related to them were the subject of a recent academic conference held at Northwestern University, near Chicago. A review of the ideas presented at this conference (BAR vol. 26, No 2, 2000) reveals clear disagreement between two groups of scholars, one of which values the Bible as an authentic document for reconstructing Jewish history, and another that considers the Bible to be made up stories representing the time from hundreds of years later when the text was composed.

When we approach the Bible as a cultural monument, we inevitably meet an intricate interlacing of mythological, historical, ethno-biological and pure poetic components. In many cases, a careful multidisciplinary approach would be helpful in the dialogue, and could strengthen appropriately either position being argued. In their arguments, each group of scholars uses systems of methods and sets of evidence convenient (and comfortable) for them and traditional for their fields to evaluate the historical authenticity of the Bible. One simple example demonstrates the usefulness of biologically oriented archeological data in the debates over the correspondence of the Bible to historical and archeological reality. As W. Dever stressed, the rarity of pig bones in the small agricultural villages that sprang up in the central hill area of Canaan during the late 13th to 11th centuries B.C.E. may be the best ethnic marker, distinguishing "Israelites" from Canaanites (1).

We do not claim expertise in either biblical studies or archeology, but, being intrigued by the debates around "biblical" and "historical" Israel and its people, we would like to present an additional powerful tool—the insights of biology and medicine. None of the opponents have used these insights in their arguments to assess the historical value of the Biblical texts. A series of publications, including some written by one of us (MG), analyzes certain portions of biblical lore from the point of view of modern biology, medicine and, specifically, human genetics. We also offer a brief review of some relevant publications and present some arguments on the genetic continuum between the people of the Bible and present day Jews, as well as genetic evidence for the reality of the Terah-Abraham genealogy in Genesis. We hope that Biblical scholars, despite their affiliations in either school, will find meaningful this biomedical approach to the search for history in the Bible.

Bible, Biology and Medicine

There is a long tradition of biomedical analysis of the Bible. For instance, Charles Darwin in his prodigious study, "The expression of the emotions in man and animals", elucidated how old the shame-blushing emotion is. "(T)he most peculiar and the most human of all expressions. Monkeys redden from passion...It is the mind which must be affected", concluded Darwin (2, page 309). He tried to establish whether peoples blushed 2000-3000 years ago. He described various patterns of blushing emotion in different races and ethnic groups, and even the inheritance of its peculiar pattern in some families. At last Darwin appealed to the Bible, finding in the book of Jeremiah (6:23) a clear indication of long-held historical knowledge: *"Nay, they were not at all shamed, neither could they blush"*. Even movements which sometimes accompany an intense blush were noticed and recorded in the Bible: *"I hid not my face from shame"* (Isaiah 1:6) and *"I am ashamed and blush to lift up my head to thee, my God"* (Ezra 9:6).

The Bible texts contain valuable information on different aspects of biology. For instance, the nearly 150 plant species mentioned in the Bible were the subject of comprehensive analysis (3,4). Medical historians have found in the biblical texts many important facts about diseases and the character of their distribution and expression, e.g, the first indication of plague epidemics and hemophilia. The Bible references numerous human diseases and disorders, many of which were analyzed in recent publications. It turns out that incredibly observant, medically literate, and detail oriented biblical writer(s) included technicalities that allow modern physicians to draw certain, and sometimes quite accurate, conclusions about the medical conditions of Biblical subjects more that two and a half millennia later. The list of diseases and afflictions is long, and includes, but is not limited to, tuberculosis, various infections, alcoholism and psychopathology, radial nerve palsy, and traumatic hip injury (5-9).

The Bible presents such detailed descriptions of various aspects of human sexuality and reproductive biology, including female infertility, post-menopausal conception, the course of pregnancy, the art of midwifery and many others aspects of this field of modern medicine, that modern obstetricians and gynecologists can analyze particular cases. Particularly, the Bible includes accounts of the pregnancies, labors, and deliveries two sets of twins (Genesis 25:21-6 and 38:27-30). The details of these twin deliveries are far more explicit than other obstetric accounts. It is apparent that "the biblical author was well-versed in the importance of the perception of fetal movement, the normal length of gestation, the general art of midwifery, and both the antenatal and intrapartum diagnosis of twins" (10).

Famous pathologist and historian of medicine William Ober conducted an in-depth, scientific analysis of the Bible narrative of infertility in Genesis from the point of modern knowledge of reproductive disorders. He clarified that, in the case of Onan's sexual behavior (Gen. 39-9), there was for centuries a misunderstanding or language confusion of

"onanism" (in the sense of masturbation) with the absolutely different situation of "coitus interruptis". Ober suggested that two brothers, Er and Onan, suffered from the same inborn hereditary defect (11). The sexual consequences of the disorder may be connected with premature ejaculation or even an arterial break and death during intercourse (famous cases of the so-called "death in the saddle"). The mythological explanation of the infertility and early deaths of Er and Onan (the Lord's punishment) may hide an evident family reproductive disorder.

The story of the Prophet Samuel and his mother Hannah (1 Sam.1:1-28), who had a problem becoming pregnant, represents another case of disorder that may be interpreted in the terms of modern medicine. Hannah desperately wanted to have a baby, but for a long time could not conceive. Being tormented and stressed by her fertile sister, Hannah stopped eating. The Biblical writer who presented Hannah's story placed an emphasis on her not eating, which makes the connection of the Biblical story with retrospective medical analysis. According to contemporary medical professionals, Hannah's condition "is the first historically documented case of anorexia nervosa—very likely brought on by depression"(12).

The evident correspondence of the Biblical text with medical realities permits us to disagree with the claim of leading Biblical minimalist T. L. Thompson about the disorientation of attempts "to transpose a perspective of reality underlying biblical traditions into peculiarly modern terms" (13, p.36). Certainly, it is by no means easy to relate each definite case of theological language and symbolism to its suggested historical or medical core. For instance, what is the symbolic sense of "year" in Genesis and the real age of patriarchs? Since the duration of "year" in the book of Judges corresponds with the modern one, King David lived 70 years. As W. Dever remarked, "even myth may contain some historical truth, even though it always seeks to convey truth to a higher order" (1, p.30).

Bible and Human Genetics

Medical references in the Bible text characterize the level of medical knowledge of the biblical writers more than providing evidence of the reality of Biblical events and people. The Bible, on the other hand, provides strong evidence for the biological reality of people and events described in the text. From the viewpoint of genetics, the Bible as a cultural monument has obvious and striking distinctive peculiarities: (i) numerous genealogical trees throughout all the books and (ii) descriptions or mentions of human genetic or hereditary disorders -- hemophilia, hirsutism and alopecia, red hair, gout, left handedness, polydactyly, etc. (14,15).

The Biblical tradition of detailed genealogical records gave Talmudic scholars the opportunity to provide advice that would today be called the earliest case of genetic counseling. Dr. R. Goodman (15) presented an amazing relevant quotation from the Talmud, *"For it was thought: If she circumcised her first and he died, and she had the second one circumcised and died, she must not circumcise her third child so stated Rabbi*

Judah Ha-Nasi. Rabbi Shimon ben Gamliel however said. She may circumcise the third child but must not circumcise the fourth if the third child dies. It once happened with four sisters from Tzippori, where the first had her son circumcised and he died, when the second sister had her son circumcised and he died, when the third sister had her son circumcised, he also died. The fourth sister came before Rabbi Shimon ben Gamliel and he told her you must not circumcise your son".

Here we have direct evidence that, based on Biblical heritage, Talmudic scholars understood the elements of so-called sex-linked inheritance in the case of recessive hemophilia mutation many hundreds of years before an occurrence of the chromosomal theory of heredity. The knowledge of inheritance of hemophilia they drew from study of human geneological records and the pattern of the appearance of human diseases. The situation that bleeding occurred during the ritual of circumcision in three sons of one woman and later in the male progeny of three sisters strongly supports the description of, as we know today, the transmission of well known X-chromosome-linked recessive type A hemophilia. Furthermore, Goodman indicated that Maimonides, the great physician and Talmudist of the 12th century, recognized that a female can transmit the disease to her male offspring even if the sons were conceived from different fathers. This peculiar type of disease transmission was scientifically formulated after the appearance of the chromosomal theory of heredity formulated by T. Morgan in the beginning of the 1910s .

Before this, classic medical theory in the case of hemophilia accepted the so-called Nasse's law published in 1820. German physician Christian Nasse stressed the fact that women can transmit hemophilia but are themselves immune to it (16). It is only a partial truth. The Bible oriented tradition demonstrates a deeper level of penetration of the intricate nature of sex-linked disease.

We focus on the detailed description of the hemophilia event for one purpose only: to demonstrate that Talmudic understanding of the intricate character of the sex-linked inheritance of this disease would be absolutely impossible without a tradition of long-term, accurate genealogical records and documentation of the predictable transmission of this trait through generations. In other words, this single example provides a strong indication of the principle reliability of the Biblical genealogical records. The pedigrees, however, are imprecise and incomplete, as discussed in the *Encyclopedia Judaica* (17). Nevertheless, inheritance and segregation of genetic traits according to genetic laws in some cases within these genealogies point out that the subjects of most biblical genealogies were real people, not merely names or symbols that represent tribes or ideas.

Analysis of Bible texts from the genetic point of view gives us a chance in one case to estimate roughly even the frequency of definite genetic variants in ancient Jewish populations of Iron Age. Using a modern neuropsychological approach, F. Fabbro found in the Bible (both Old and New Testaments) references to ten (!) distinct aspects of phenotypical expression of left-right human asymmetry (18). According to the widely accepted model, left-right asymmetry is inherited in a single gene with two of its variants (alleles) R and r. Left handed peoples are recessive "rr" homozygotes and children of a left

handed father and mother must be exclusively or mostly left-handed. Carriers of two dominant alleles RR—are obligate right-handed people. At the same, time, "Rr" heterozygotes are predominantly right-handed or may have similar left and right activity.

The book of Judges, describing events between 1200 and 1025 B.C.E., reports in detail the heroic deeds of Ehud *"a left-handed man, the son of Gera the Benjamite"* (Judges 3:15). Due to his left-handedness, Ehud succeeded in killing Eglon, the king of Moab overpowering the Israelites. Then the Bible informs us of the high distribution of left-handedness among the Benjamites and presents the quantitative data: *"seven hundred chosen men who were left-handed"* among 26,000 (Judges 20:15). This gives a frequency of 2.6% of recessive left-handed peoples. According to principles of population genetics, we may figure that nearly 25% of Rr heterozygotes are capable of similar left-right activity. And again we meet in the Bible the clear indication of this genetically expected fact! Chronicles (12:2) mentions warriors of Saul from the tribe of Benjamin who joined David and "were able to shoot arrows or to sling stones right-handed or left-handed". In genetic language, these warriors were dextrous Rr heterozygotes.

Now, using standard methods of population genetics, we may compare the frequency of recessive left handed homozygotes in the ancient Benjamite population and in modern Jewish communities. R. Goodman in 1972 conducted a detailed study of left-handedness among various presently living Jewish ethnic groups. He found statistically significant differences among the frequency of homozygotes: Ashkenazi—7 %, Sephardic—10%, North Africans—5% and Yemenites—3,5% (14). Apparently these population genetics data correspond well with the biblical description both for the general frequency of this hereditary feature and for its fluctuation in various ethnic groups.

New achievements in molecular genetics, including DNA finger printing and fine chromosome analysis, open new, amazing possibilities for further study of the correspondence between genetic and historical data and the search for history in the Bible. Human females transmit their DNA-containing cytoplasmic organelles called mitochondria on maternal lineages. But males inherit their Y-chromosome only paternally. It follows that some genetic markers or traits are inherited maternally, whereas others only paternally. Thus, each of us carry physical evidence (genes and chromosomes) of the genetic events that happened with our ancestors many generations ago, even hundreds and thousands of years. Therefore, the mode of exclusive paternal and/or maternal inheritance represents a unique tool for paleogenetics to study the effect of historical and ethnic processes on the human genome and on human populations. Study of the genetic makeup of presently living human populations with this genetic tool gives a direct estimate of the level of admixture between different human populations that occurred many generations ago.

Paternal (patrilinear) inheritance of the Y-chromosome leads to very important consequences. All male descendants of a single man will have the same Y chromosome, regardless of how many generations later the boy is born. According to the Old Testament tradition, the male descendants of a single person with the name Aaron, Moses'

brother, were selected to serve as Priests (Cohanim) for the other Jews (Exodus 28:1-3). The priesthood among Jews through the generations was followed by a patrilineal inheritance of the Y chromosome variant with unique molecular markers. Indeed, it appears that although Levite (non-Cohen) Y-chromosomes are diverse in their molecular pattern, the "Cohen" chromosomes are different from the "non-Cohen" chromosomes, and are molecularly and genetically similar since they have a common origin. Thorough ethno-genetic studies provided by the scientists of the Center for Genetic Anthropology, University College, London, and their colleagues, allow us to "trace the origin of Cohen chromosomes to about 3000 years before present, early during the Temple period" (19). The amazing finding that "Cohen-specific" Y-chromosome variants turn out to be homogenous for all Cohanim, of both Ashkenazic and Sephardic origin, may serve again to prove the strong paleogenetic confirmation of historical reliability of the main genealogical records in the Bible and their maintenance and long-term transmission through centuries. More importantly, the rate of gene mutation which is commonly accepted in paleogenetics, or, "genetic clock", allows these authors to estimate a *coalescent time*, the time at which the Cohen chromosomes were derived from a common ancestral chromosome. The coalescent time in this instance corresponds to the biblical time of the first Temple (!).

Other similar studies elucidated the ethno-genetic status of Falasha and Ethiopian Jews who recently migrated to Israel. Both ethnic groups speak Amharic and claim to be descendants of Jews who came to Ethiopia with Menelik 1, the alleged son of King Solomon and the Queen of Sheba. Molecular DNA analysis shows that Falasha peoples descended from ancient inhabitants of Ethiopia who converted to Judaism, but the Ethiopian Jewish community has a mixture of Y-chromosome variants. Similar studies confirm an oral tradition of the Jewish origin of the Lemba, bantu-speaking "Black Jews"from South Africa. Indeed, it turned out that nearly 50% of their Y-chromosome is of Semitic origin and nearly 40% is Negroid (20,21).

Using the same Y-chromosome based approach, an international group of human geneticists in a recently published paper (22), established several molecular, population and paleogenetic facts that confirm the history of the entire Jewish nation, known to us from the biblical text and other sources of history. Particularly, the authors clearly demonstrated that Jews, Palestinians, Syrians and Lebanese descended from the historically common population that "inhabited the Middle East some 4,000 years ago". Furthermore, molecular genetic analysis of the representatives from the European and Middle Eastern Jewish communities allows them to trace the pattern of the Jewish diaspora from 586 B.C.E. to the modern time.

Genetics and reality of the Abraham genealogy

After this inevitable large prelude, we will now demonstrate how new genetic knowledge supports the historical reality of the people known to us as the biblical Abraham family.

As shown in *Encyclopedia Judaica,* some genealogical trees in the Old Testament have small or significant controversies in their branches, with evident symbolic and theological installations and rearrangements. The biblical genealogies are clearly uneven in the sense of their completeness and reliability (17). The Abraham pedigree tree looks in many relations extraordinary, as follow from the detailed analysis provided by R.Willson (23).

Actually, the only purpose of this part of our paper is to provide genetic evidence proving that behind the biblical names of the patriarchs and their children and grandchildren stood real people. We mean the biological reality of individuals, not tribes called "Abraham", "Isaac", "Jacob" and others, but real people as indicated in the fragment of a genealogical tree in Fig.1 drawn in accordance with the indications of Genesis (11-50) and widely used principles of "genetic algebra" (24).

According to the Biblical narrative, Terah was the leader of a small tribe living in Mesopotamia. "*Terah begat Abram, Nahor and Haran: and Harran begat Lot. And Haran died before his father Terah in the land of his nativity, in Ur of the Chaldees. And Abram and Nahor took themselves wives; the name of Nahor wife's was Milcah, the daughter of Haran*". According to the Bible, the tribe migrated from Ur to Haran in upper Mesopotamia. Then Abram, later named Abraham, left Haran and together with Sarah and his nephew Lot "*went forth to go into the land of Canaan; and into the land of Canaan they came*" (Gen. 12:15).

The fragment of pedigree pictured in Fig.1 shows many elements typical to marriage customs within small ancient populations, e.g. close kinship and polygamy. For instance, Abraham married his half-sister, Sarah, who was, according to the records, Terah's daughter from another wife. "*She is daughter of my father, but not the daughter of my mother, and she became my wife*" (Gen.20:12). Similarly, Rebekah, wife of Isaac, was his first cousin by her father's line but his great niece by her mother's line. As the records showed further, Jacob married his two cousins, Leah and Rachel. We can assume that the time covering that pedigree was in the pre-Moses period, since incest between a father and his daughter was recorded in the same family (Lot and his daughters) (25). Stricter sexual regulations, however, were introduced late and fixed in the Bible in the post Moses period (Levit.18:21).

We analyzed in detail the traditionally accepted genealogy of Abraham from the point of reproductive biology and genetics.

The starting point for this analysis was that one of us (MG) found an unusual hereditary disorder in a Jewish family in 1984. He described the inheritance of one rare mutation inducing reproductive disorders with the opposite phenotypical effect, e.g. male or female

infertility coupled with a tendency to give birth to twins (26). Reproduction biology differentiates sterility from infertility. Sterility is the total absence of progeny, while infertility is a delay in reproduction or detrimental conditions that partially affect the ability to conceive and produce offspring. New discoveries in reproduction biology and cytogenetics make it possible for him to identify this peculiar hereditary abnormality as ITPD syndrome or Infertility—Twinning Paternally Dependent syndrome. The relevant report was presented in 1998 at the IX International Congress on Twin Studies (27).

The association of infertility with a birth of twins in the same family may result from an unusual biomedical event -- fertilization of a single egg by more than one sperm. According to the hypothesis, there are some paternal genes that begin to function already in spermia and promote bispermal fertilization of the single egg. This event leads predominantly to a chromosomally abnormal embryo and its abortion (infertility). But in rare outcomes, double fertilization may produce viable twins. Such unusual twins could be less similar than identical, but more similar than non-identical twins. There is also the theoretical possibility of the appearance of unusual genetically chimeric individuals in such families. The whole expected complexity of this syndrome has been described in the appropriate publications (27,28).

The Abraham pedigree represents a classical example of simultaneous occurrence of impaired fertility and twinning. The question was, however, is the simultaneous occurrence of infertility and twinning recorded in the Bible a coincidence or did it result from a genetic disorder? Since marriages between close relatives, as happened in the Abraham family, favor the distribution of recessive mutations in progeny and segregation in a homozygote state, this unique pedigree could answer this question. It might also provide, even for the present time, valuable scientific information on the inheritance of mutations affecting both fertility and twinning. A report concerning the possible genetic aspects of transmission and expression of this mutation in the Terah-Abraham genealogy was published in Israel in 1986 (29).

Specifically, according to the Bible text, Abraham's wife, Sarah, *"was barren; she had no children"* (Gen.11:30). Abraham did, however, have children by his two concubines, Hagar and Keturah (only the lineage from Hagar is shown in Fig. 1). Putting aside the theological and mythological context, the medical fact is clear: after many years of infertility, Sarah conceived in the postmenopausal period. In the frame of assisted reproduction technology, the potential for successful pregnancy many years beyond natural menopause was recently shown. A successful pregnancy and normal infant birth by oocyte donation was achieved by a woman at the age of 63 (30).

Rebekah, the wife of Abraham and Sarah's son Isaac, was his first cousin. She, according to the Bible, also suffered from infertility. After 20 years of marriage she was childless. *"And Isaac entreated the Lord for his wife, because she was barren and the Lord was entreated of him, and Rebekah his wife conceived"*(Gen.29:31). Rebekah at last gave birth to non-identical twins, Esau and Jacob.

Jacob's two wives, Leah and Rachel, were his cousins (Fig.1). Once again, one of them suffered from infertility: "*And when the Lord saw that Leah was hated, he opened her womb but Rachel was barren*" (Gen. 29:31). Apart of theological explanation, the medical core for the apparent difference in fertility between the sisters may be explained as a well-known segregation of a Mendelian mutation inducing a reproductive disorder. Accordingly, Laban, brother of Rebekah, may have been a heterozygous carrier of the mutation inducing this reproductive failure. Thus, one of his daughters (Rachel) may be homozygous and the other heterozygous on the detrimental factor. The reproductive difference between the sisters was maintained even after Rachel gave birth to her first son Joseph and she died giving birth to her second son, Benjamin. Her sister, Leah gave birth to six sons and one daughter (Gen. 30:20-21).

It is apparent that Rebekah, Laban's sister, also suffered from the same mutant gene, which appears to have been inherited by Sarah from Terah. It seems Terah, the founder of the tribe, was the original carrier of the impaired fertility mutation. Thus, we can recognize in this genealogy tree a "Founder's principle", which is well known in medical and population genetics for small inbred human families. Inherited reproductive disorder in the Terah-Abraham lineage apparently affected both females and males. For instance, two grandsons of Leah, Er and Onan were married to Tamar. Both marriages were childless. Yet, Tamar after only one curious intercourse with their father Judah (Leah's son) gave birth to the twins Pharez and Zarah (Gen. 38:27). It is another clear example that the expression of infertility in this lineage is linked to the twinning.

In genetic terms, the birth of twins resulting from the intercourse of Judah and Tamar coupled with the reproduction disorders (infertility) of his two sons may serve as the historically first reported example of direct paternal influence on both infertility and twinning.

The mutation transmitted in the Terah-Abraham family is evidently semi-dominant with incomplete and varying visible expression. It means that only some carriers of this mutation in succeeding generations will express described reproductive abnormalities. In genetics, such mode of inheritance has a specific term --"skipped generations". Hence, we may expect the action of this mutation in only some successive generations in the Judah descendants. Having in mind the logic of "skipped generations", we searched for an indication of ITPD syndrome expression in the genealogical trees described in the biblical book of Chronicles.

If Judah were the carrier of the above-mentioned mutation, he might transmit the ITPD to one or both of his twin-sons, Pharez and Zarah. In the book of Chronicles genealogical list, namely in Pharez' progeny, there are clear mentions of further hereditary transmission of this mutation. The Bible indicates a six generation genealogical lineage Juda-Pharez-Hezron-Jerahmeel-Onan–Shammai. But then it is recorded: "*Sons of Shammai Nabad and Abishur... and the sons of Nabad: Seled and Appaim: and Seled died without children... and the sons of Jada, the brother of Shammai: Jether and Jonathan; and Jether died without children*". (1 Chron.2:28-32).

It is apparent that the rather complex biblical lineage records shown in the Terah-Abraham genealogy, coupled in some cases with detailed medical and obstetric notes on the expression of the definitely hereditary reproductive disorders, simply could not have been invented. As geneticists, we absolutely exclude that. The ability to trace this disorder through several generations of biblical characters and the discovery of a similar pedigree in a modern Jewish family increases the reliability of our firm conclusion that the Biblical description of the Terah-Abraham lineage reflects real biological and historical events and people.

Conclusion

From a religious and theological point of view, the level of historicity of the Bible has no serious importance. It may partially explain the opinions (like that of Rabbi S. David Sperling) (31), that the Bible seems to have been just an invention by one or several authors as a reason to inspire other Jews to believe in God. We have presented genetic data evidencing the historicity of the Bible and its main figure Abraham, the progenitor of three monotheistic religions.

Genetic records and information are considered to be acceptable physical evidence in civil and criminal court decisions, in heritage arbitrations, and in acceptance of various socio-economic laws. Similarly, the genetic data derived from the biblical text can be accepted as physical evidence when discussing the historical reality of the biblical text. The genetic material discussed above clearly demonstrates that the facts and events described in some portions of the Bible conform to extra-Biblical records and surface in the genetic make up of modern Jews, the descendants of people known to us as ancient Jews. We may even imagine that, in some aspects, the Bible's genetic evidence is more reliable than the discovery of a mummy together with a sign saying who is buried, because mummy replacement is possible.

However, from the point of biomedical studies, human population and molecular genetics, the Biblical heritage remains a reliable stronghold for further historical reconstruction. The puzzling question arises of how the record of the Terah-Abraham genealogy started, since the 18th century B.C.E. is transmitted through many centuries with such striking biological and historical details. And why in successive periods did the Old Testament fail to conserve comparably detailed records of other genealogical fragments? It is a subject of promising debates.

Acknowledgments

We thank Ms. Kaye Vivian for help in preparing this manuscript, many fruitful comments and critical reading.

Figure Legend

A fragment of the pedigree of Terah-Abraham kindred. It shows the hereditary transmission of a dominant mutation with an incomplete penetrance and expressivity causing disturbances of the reproductive system (in both sexes) and a tendency to twin births. Since spouses are often related between generations, the marriage lines are often not horizontal. The persons affected by partial infertility are shown by shaded circles and squares. Twins, Esau and Jacob, Pharez and Zarah, are depicted by the closed squares. The "⊥" symbol indicates Abraham-Sarah, Isaak-Rebekah, Er-Tamar and Onan-Tamar marriages afflicted by the infertility factor.

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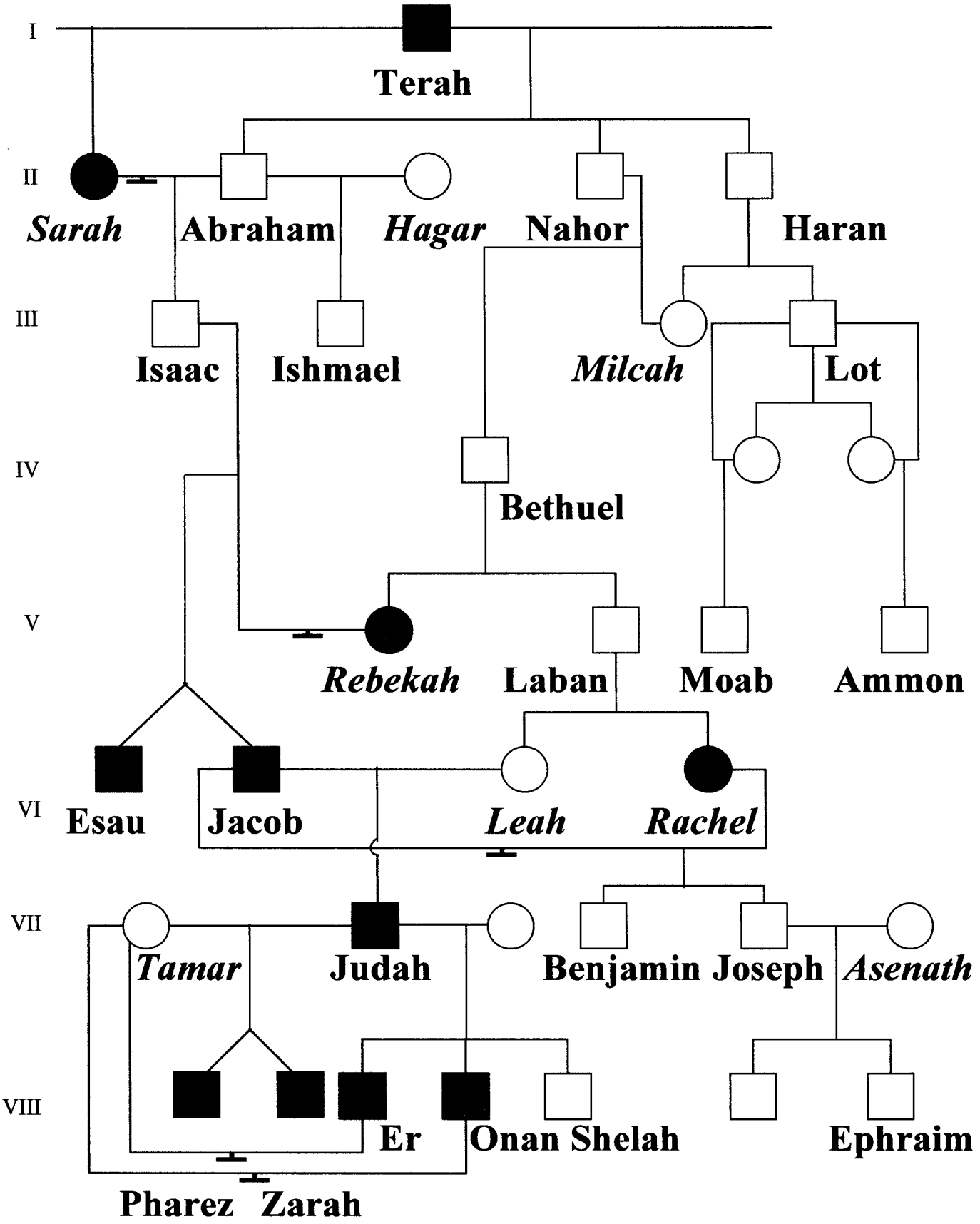
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